**Heliophysics Technology And Instrument Development For Science**

# Properties of kinetic magnetic reconnection.

Completed Technology Project (2018 - 2021)

## Project Introduction

Step 1 proposal to ROSES 2017 Heliophysics Research Program B.3; 1.4 (LNAPP) PI: Jan Egedal (U. Wisconsin)( Co-Investigators: Cary Forest (U.Wisconsin) Collaborators: William Daughton (LANL), Tai Phan (SSL) Magnetic reconnection plays a fundamental role in nearly all magnetized plasmas as it enables magnetic energy to be converted into high-speed flows and thermal energy. It allows the magnetic field lines to change topology in collisionless plasmas, thereby controlling the spatial and temporal evolution of explosive phenomena such as solar flares and coronal mass ejections. Of special interest for the Sun-Earth connection and plasma conditions in the near Earth environment, reconnection in the dayside magnetopause and in the Earth's magnetotail is the dominant process that couples the solar wind to the Earth's magnetosphere. In this proposal, using the Terrestrial Reconnection EXperiment (TREX), we will experimentally address the questions of: 1) How does the reconnection rate scale with the asymmetric inflow condition? 2) Is the onset of reconnection suppressed in the limit of a strong guide magnetic field (low magnetic shear angle)? and 3) What is the role of electron pressure anisotropy in shaping structure and dynamics of the electron diffusion region? The scientific interest for these questions is rooted in reconnection observed in the solar wind. Furthermore, in the dayside magnetopause, the relatively dense plasmas from the solar wind reconnect with magnetospheric plasmas that have densities about two orders of magnitude less. The scientific focus on kinetic aspects of asymmetric reconnection has intensified with the remarkable new data now available from the completed Phase I of NASA's MMS mission on asymmetric reconnection in the dayside magnetopause. Complementary to spacecraft observations, laboratory experiments have the advantage that the reconnection physics can be isolated and studied under controlled and repeatable plasma conditions. However, so far the high collision frequency between electrons and ions has prevented laboratory experiments to reach a regime where pressure anisotropy and non-Maxwellian distribution functions can develop. The present proposal is similar to a well-reviewed proposal we submitted to the similar solicitation in 2016. As a major new development, with our recent experimental upgrades, TREX is the first reconnection experiment to realize plasma conditions where electron pressure anisotropy can develop unimpeded by collisions. Contrary to data obtained in the more collisional MRX experiments, preliminary data from our collisionless regime confirm key aspect of kinetic simulation results, such as the narrow electron layers that develop within the reconnection diffusion region. Thus, the TREX configuration provides an unparalleled opportunity to study reconnection in the laboratory under collisionless conditions directly relevant to the Earth's magnetosphere. In addition to the experimental expertise provided by PI Prof J. Egedal and CO-I Prof C. Forest, our team is augmented by Collaborator W. Daughton, who will provide kinetic simulation data matching the experimental setup and by Collaborator T. Phan, who will provide guidance in selecting experimental plasma conditions relevant to observations in the magnetopshere. The requested funds will mainly support TREX engineer J.

Image Not Available

Properties of kinetic magnetic reconnection.

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## Organizational Responsibility

**Responsible Mission Directorate:**

Science Mission Directorate (SMD)

**Lead Organization:**

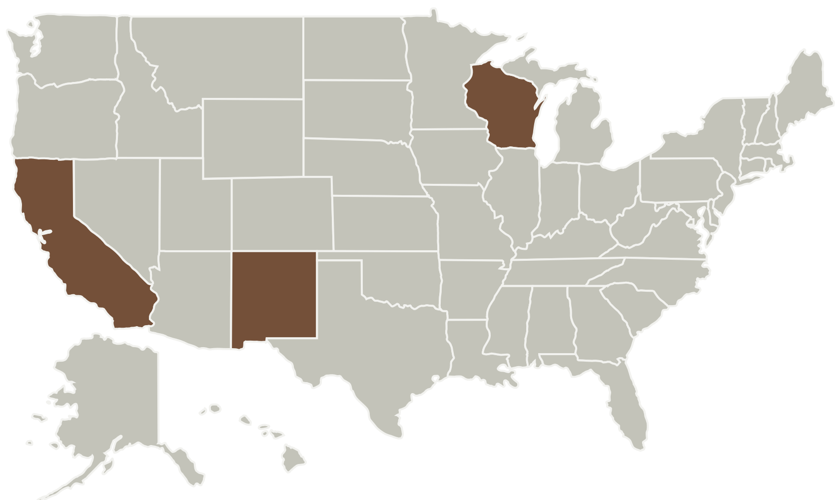
University of Wisconsin-Madison

**Responsible Program:**

Heliophysics Technology and Instrument Development for Science

Wallace, technician M. Clark, and graduate student S. Greess. The proposed work addresses the actions under Goal 1 and 4 for Solar and Heliospheric Physics in the last Decadal Survey: Goal 1: Determine the origins of the Sun's activity and predict the variations of the space environment. Goal 4: Discover and characterize fundamental processes that occur both within the heliosphere and throughout the universe.

### Primary U.S. Work Locations and Key Partners



| Organizations Performing Work | Role | Type | Location |
|---|---|---|---|
| University of Wisconsin-Madison | Lead Organization | Academia | Madison, Wisconsin |
| Los Alamos National Laboratory(LANL) | Supporting Organization | R&D Center | Los Alamos, New Mexico |
| Research and Sponsored Programs - University of Wisconsin | Supporting Organization | Academia | Madison, Wisconsin |
| University of California-Berkeley(Berkeley) | Supporting Organization | Academia | Berkeley, California |

## Project Management

**Program Director:**
Roshanak Hakimzadeh

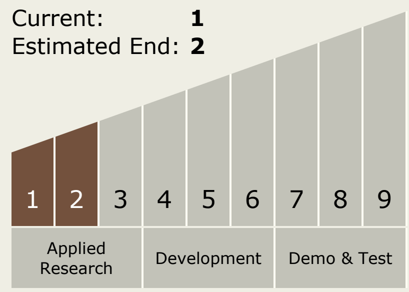
**Program Manager:**
Roshanak Hakimzadeh

**Principal Investigator:**
Jan Egedal

**Co-Investigators:**
Tai D Phan
Brenda Egan
William S Daughton
Cary Forest

## Technology Maturity (TRL)

Start: **1**
Current: **1**
Estimated End: **2**




## Technology Areas

**Primary:**

- TX08 Sensors and Instruments
  └ TX08.1 Remote Sensing Instruments/Sensors
    └ TX08.1.1 Detectors and Focal Planes

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| Primary U.S. Work Locations | |
| --- | --- |
| California | New Mexico |
| Wisconsin | |

## Target Destination
The Sun